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# OCCURRENCE AND AVAILABILITY OF HELIUM IN THE USSR

CIA/RR MP-238

27 June 1958

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CENTRAL INTELLIGENCE AGENCY

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## FOREWORD

In October 1957 the Economic Intelligence Committee (EIC) Subcommittee on Chemicals assigned high priority to determining the level of production of helium in the USSR because of the use of helium in guided missiles and nuclear energy and its other strategic applications. Inasmuch as the only known commercial source of helium is helium-bearing natural gas, the problem was referred to the EIC Subcommittee on Petroleum.

In November 1957 the EIC Subcommittee on Petroleum agreed that the level of production of helium in the USSR could not be estimated on the basis of the information available. It was recommended that a report be prepared on helium in the USSR with emphasis on the probable occurrence of helium-bearing natural gas and on the amount of helium which might be extracted from such gas. This report undertakes to meet that need.

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# OCCURRENCE AND AVAILABILITY OF HELIUM IN THE USSR*

## Summary

The USSR probably has about 1.4 billion cubic feet** of helium available from the helium-bearing natural gas*** being produced in that country in 1958. In the US, about 4.2 billion cubic feet of helium are available each year, although the capacity of helium plants has been developed to extract only about 0.35 billion cubic feet annually. By the fiscal year 1960,**** however, it is expected that the capacity of these plants will be expanded sufficiently to permit the extraction of nearly 0.5 billion cubic feet in order to meet strategic requirements.

Although there are several indications of production of helium in the USSR, data are not sufficient to develop an estimate of the volume of Soviet production. If helium is being extracted from one-fourth of the helium-bearing natural gas believed to be available in the USSR, Soviet production would be about equal to that of the US, or approximately one million cubic feet per day. No other country is known to produce helium on a large scale.

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## 1. Helium-Bearing Natural Gas in the USSR.

### a. Geological Potential.

Petroleum, in the form of both crude oil and natural gas, is found in commercial quantities only in sedimentary basins or other

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* The estimates and conclusions contained in this report represent the best judgment of ORR as of 1 June 1958.

** Volumetric measurements of helium and gas throughout this report refer to the volume at standard atmospheric temperature and pressure.

*** Theoretically, helium can be extracted from the atmosphere, but the cost is exhorbitant. 1/ (For serially numbered source references, see Appendix E.) In this report, all references to the availability, recovery, and production of helium apply exclusively to helium in helium-bearing natural gas.

**** Data on the US are reported on the basis of fiscal years by the Bureau of Mines of the Department of the Interior, which is charged with production of helium in the US.

sedimentary areas of the earth. Both the US and the USSR have more than average incidence of such sedimentary areas. The US, with 5 percent of the total land area of the world, has 12 percent of the total sedimentary area, or 2.5 million square miles. The USSR, with 14 percent of the total land area of the world, has 20 percent of the total sedimentary area, or 4.3 million square miles.* 2/ Thus the sedimentary area of the USSR is 1.7 times that of the US, and therefore the potential resources of natural gas in the USSR may equal or exceed those of the US. The wide diversity of geological conditions under which these resources occur in the USSR may be compared to the range of geological conditions in the sedimentary areas of the US. 3/ On the basis of known conditions in the US, there is strong evidence that the USSR possesses natural gas containing helium in recoverable quantities.

b. Probable Occurrence and Distribution.

On the basis of experience in the US, two indications of recoverable helium in natural gas in the USSR are the presence of nitrogen in quantities of 2 percent or more in the natural gas and the production of natural gas from the older sedimentary rocks of the Paleozoic age. Such deposits of natural gas are still more likely to contain helium in recoverable quantities if they overlie buried granite ridges or are in an area of igneous intrusions.*

A survey of the areas in the USSR which produce natural gas has resulted in the selection of four areas as the most likely to possess recoverable quantities of helium.

(1) Ural-Volga Area.

A scientific monograph appearing in 1955 contains the only published analyses of natural gas in the USSR that specify the helium content. 4/ The monograph reported that 17 analyses of natural gas from the Ural-Volga area showed a helium content ranging from 0.001 to 0.955 percent. Seven of the analyses showed a helium content of more than 0.4 percent.**

Scrutiny of 74 analyses of natural gas produced in this area shows only 2 with a nitrogen content of less than 2 percent, and less

* See Appendix A.

** In the US the Bureau of Mines has determined that, under existing conditions, helium cannot be recovered economically from natural gas that contains less than 0.4 percent helium.

than one-half of the analyses show a nitrogen content of less than 10 percent.* 5/ Another source shows that in four important fields producing natural gas in this area (Buguruslan, Ishimbay, Syzran', and Tuymazy) the nitrogen content of the gas varied from 11.0 to 31.5 percent. 6/ Most of the natural gas produced in the area comes from older Paleozoic rocks of the Devonian period. 7/ Except for the southeastern part of the area, the Devonian formation overlies granites and other crystalline basement rocks. 8/

(2) Pechora River Basin.

The Pechora River basin, which is north of the Ural-Volga area, has produced natural gas for several years. The geological conditions in this basin are reported to be similar to those in the Ural-Volga area. 9/ Published analyses of 23 samples of natural gas from this area show a nitrogen content ranging from 4 to 11 percent. 10/ This area is isolated and could be the site of an unreported plant for the extraction of helium.

(3) Stavropol'skiy Kray.

In September 1957 a broadcast from Moscow claimed the discovery in Stavropol'skiy Kray of a large deposit of pure helium at a depth of 3,000 meters, or 1,000 meters below the zone producing natural gas. 11/ According to the broadcast, Belov, the chief geologist of the oil and gas industry at Stavropol', estimated that the deposit was very large and added that deposits of pure helium were a very rare phenomenon. No additional information on this reported discovery has been released.

There is considerable doubt as to the reliability of this broadcast. A natural deposit of pure helium is unprecedented -- the richest helium-bearing gas discovered in the US contains 8.34 percent helium. 12/ Furthermore, although large deposits of natural gas have been found and developed in recent years in Stavropol'skiy Kray north of the Caucasus Mountains, most of the published analyses of natural gas produced in this area do not suggest the presence of helium, because the nitrogen content is less than 2 percent. 13/ Only 3 out of 18 analyses show a nitrogen content ranging from 4.2 to 6.5 percent. Although there are indications that older Paleozoic rocks underlie a part of the area and a spur of igneous intrusions extend into the area

* In analyses of natural gas in both the US and the USSR the percentage shown as nitrogen includes helium and other rare gases unless such gases are shown separately. In the US, helium is shown separately in the analyses reported by the Bureau of Mines.

from the Caucasus Mountains, most of the natural gas produced in this area is obtained from rocks formed since the Paleozoic age, a circumstance which does not favor the occurrence of helium. 14/

(4) Dnepr-Don Basin.

Recent discoveries of natural gas in the vicinity of Khar'kov in the Dnepr-Don basin have shown a nitrogen content as high as 23.9 percent. 15/ Some of these newly discovered deposits are of the Paleozoic age, and a substantial Paleozoic section may underlie this area. 16/ There is also an igneous intrusion adjoining the area on the south. 17/ These positive indications of helium-bearing natural gas in the new and extensive deposits that are being discovered and developed in this area suggest that substantial quantities of helium may be available.

The selection of the four areas cited above does not preclude the existence of other undiscovered or undeveloped deposits of natural gas which may contain helium in recoverable quantities.

2. Availability of Helium in the USSR.

a. Technology of Extraction.

The availability of helium depends not only upon the occurrence and production of helium-bearing natural gas but also upon the technical ability to extract the helium from such gas. The following chronological review of significant developments regarding the extraction of helium from natural gas in the USSR will indicate the level of Soviet technical ability in the use of this process.

As early as 1934 the USSR was sufficiently interested in helium to contract with US nationals for a report on the extraction of helium from helium-bearing natural gas. Although the report was prepared by a recognized authority in this field, it contained little that had not been published previously.

There is evidence that during 1946-54 a plant was built in the USSR near Moscow on the Saratov-Moscow gas line to liquefy large quantities of natural gas. The liquefied gas is stored for subsequent use during periods of greatest demand. Because liquefaction of helium-bearing natural gas is essential to the recovery of the helium, a plant which liquefies natural gas may include the relatively small amount of additional equipment needed to recover any helium contained in the gas.

In 1946 the USSR ordered equipment for the liquefaction plant from suppliers in the US. 18/ The equipment was designed to liquefy natural gas at the rate of 176,400 cubic feet per hour, to be stored in 100 metal cylinders each 10 feet in diameter and 40 feet high. 19/ Although a few of the items requested had been embargoed to the Soviet Bloc by the US, most of this equipment was shipped to the USSR. An article published in Moscow in 1956 indicates this plant was completed substantially as planned and was operating in a satisfactory manner. 20/ The design, construction, and operation of the liquefaction plant indicates that the level of technology in the USSR is adequate to extract helium from natural gas.

A limited survey of the relatively large volume of technical Russian-language literature which became available during 1955-57 yielded a brief article on the extraction of helium from natural gas in the USSR. 21/ The article indicates that in the pretreatment of natural gas preparatory to the extraction of helium, operating practice in the USSR in 1956 was on a level with that in the US in 1941. The author stated that the alkali batch process was being replaced by the continuous monoethanolamine process in production of helium in the USSR. This pretreatment involves the use of the continuous Girbotol process using monoethanolamine, which was patented in the US and which replaced the alkali batch process during World War II. 22/ Another article appearing in Russian-language literature describes the US helium industry and includes a 13-item bibliography of data on helium published in the US during 1945-56. 23/

That the USSR has achieved a significant technologic advance over the US in the production and transportation of liquid helium is indicated by a recent report. 24/ This report quotes Dr. Peter L. Kapitsa, Director of the Institute of Physical Problems, as saying that liquid helium is so abundant in the USSR that it is shipped in railroad tank cars. Helium must be cooled to a temperature of -452° F, within a few degrees of absolute zero, in order to liquefy it, and it must be maintained at that temperature if it is to remain in the liquid state. Although liquid helium is produced in the US for laboratory uses, production of liquid helium in large quantities and its transportation by railroad tank cars is beyond actual operating technology in the US. The advantages of liquefying helium for transportation, however, are recognized in the US by the Bureau of Mines and the Navy Bureau of Aeronautics. Conventional methods of transporting helium in the US in 1955 are shown in Figure 1.* Another report indicates that Soviet ability to liquefy helium in large quantities was potential rather than actual as late as July 1957. 25/

* Following p. 6.

The foregoing evidence demonstrates that the USSR possesses the technical ability essential to the large-scale extraction of helium from natural gas.

b. Recovery from Natural Gas.

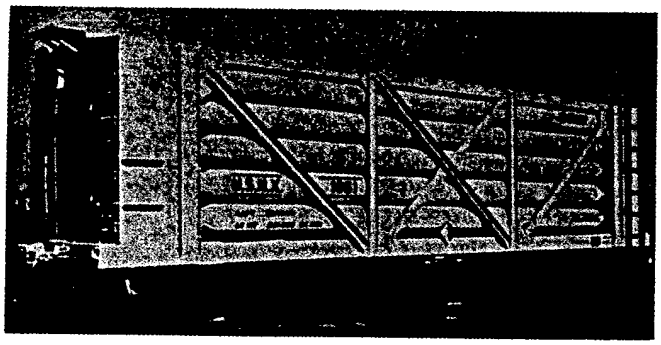
As previously indicated,* four areas in the USSR produce natural gas that probably contains recoverable quantities of helium. Estimates of production of natural gas in these areas during 1956-58 are shown in Table 1.**

As shown in Table 1, production of natural gas in the four areas of the USSR most likely to possess recoverable quantities of helium amounted to 229 billion cubic feet in 1956 and is expected to increase to 716 billion cubic feet in 1958. In 1956, production of natural gas in similar areas of the US -- western Texas, western Oklahoma, western Kansas, and New Mexico -- amounted to 2,095 billion cubic feet. 26/ It is estimated that the helium available for recovery from that portion of this gas containing 0.4 percent helium or more amounted to 4 billion cubic feet, 27/ representing 0.19 percent of all of the natural gas produced in these areas of the US in 1956.

If the areas of the USSR producing helium-bearing natural gas should have a potential for recovery of helium comparable to that of areas in the US listed in the preceding paragraph, the USSR would have 1.36 billion cubic feet of helium available for recovery in 1958. In the absence of more specific data on helium in the USSR, an estimate of 1.4 billion cubic feet per year is believed to be the best that can be made at this time.

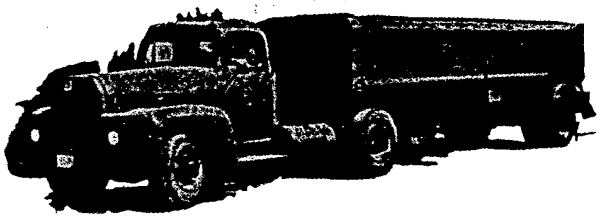
* See 1, b, p. 2, above.
** Table 1 follows on p. 7.

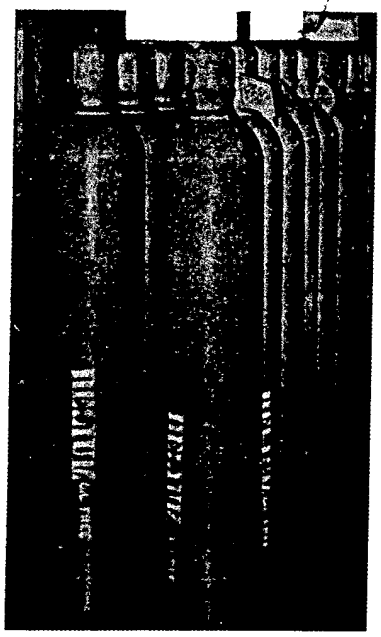
Helium is shipped to points of consumption in railway tank cars, automotive trailers, and standard compressed gas cylinders.



RAILWAY TANK CAR:
AVERAGE CAPACITY 212,600 CUBIC FEET
COST $86,600

AUTOMOTIVE TRAILER:
CAPACITY 34,300 CUBIC FEET
COST $10,000 est.





STANDARD COMPRESSED GAS CYLINDERS:
CAPACITY 192 TO 236 CUBIC FEET
COST $40

FREIGHT CAR LOAD 700 CYLINDERS ~165,000 CU.FT.
TRUCK LOAD 210 CYLINDERS ~49,500 CU.FT.

Figure 1. Data on Helium Shipping Containers Used in the US, 1955

Table 1

Estimated Production of Natural Gas in Selected Areas of the USSR
1956-58

Billion Cubic Feet

| Area | 1956 | 1957 | 1958 |
|---|---|---|---|
| Ural-Volga | 113 a/ | 173 b/ | 275 c/ |
| Pechora River basin | 39 d/ | 60 b/ | 95 c/ |
| Stavropol'skiy Kray | 35 e/ | 53 b/ | 141 f/ |
| Dnepr-Don basin | 42 g/ | 67 b/ | 205 h/ |
| Subtotal | 229 | 353 | 716 |
| Others i/ | 198 | 300 | 322 |
| Total | 427 j/ | 653 k/ | 1,038 l/ |

a. 28/
b. Estimated by assuming an increase of 52.9 percent, the rate at which production in the USSR as a whole in 1957 exceeded that in 1956.
c. Estimated by assuming an increase of 58.9 percent, the rate at which production in the USSR as a whole in 1958 is expected to exceed that in 1957.
d. The reported production of natural gas in Komi ASSR in 1956 was 39 billion cubic feet. 29/
e. The reported production of natural gas in the North Caucasus in 1956 was 40 billion cubic feet. 30/ It is believed that about 35 billion cubic feet of this total comes from the gasfields in Stavropol'skiy Kray. Some natural gas is produced in the old oilfields at Groznyy and Maykop in the North Caucasus outside Stavropol'skiy Kray.
f. The planned increase in production in 1958 compared with that in 1957 is 88 billion cubic feet. 31/
g. Estimated by assuming an increase of 52 percent, the rate at which production in the Ukraine as a whole in 1957 exceeded that in 1956. 32/
h. 33/
i. Derived by subtraction of production in the four selected areas from the total production in the USSR.
j. 34/
k. 35/
l. 36/

APPENDIX A

PRODUCTION OF HELIUM IN THE US

1. Distribution.

Natural gas with a helium content ranging from a trace (less than 0.01 percent) to 8 percent is found throughout the US. During the period 1918-47 the Bureau of Mines obtained and analyzed a sample of natural gas from each of 1,940 wells in 27 states. The distribution of the helium content in these samples is shown in Table 2.

Table 2

Helium Content of Natural Gas from 1,940 Wells in the US a/
1918-47

| Helium Content (Percent) | Number of Samples | Proportion of Total Samples (Percent) |
|---|---|---|
| None | 224 | 11.6 |
| Trace (less than 0.01) | 167 | 8.6 |
| 0.01 to 0.99 | 1,399 | 72.1 |
| 1.00 and more | 150 | 7.7 |
| Total | 1,940 | 100.0 |

a. 37/

Analysis of these samples shows that helium in recoverable quantities (0.4 percent and more) occurs almost exclusively where the natural gas is produced from the older sedimentary rocks, primarily those of Paleozoic age, and where the natural gas contains 2 percent or more of nitrogen.*

These conditions indicate only the possible presence of helium; natural gas produced under such conditions does not necessarily contain helium. Natural gases containing recoverable quantities of helium also are found usually in areas overlying buried granite ridges or associated with igneous intrusions. 38/

* For methodology see Appendix C.

2. Availability. 39/

The Bureau of Mines estimates that, on the basis of a minimum helium content of 0.4 percent, there are about 120 billion cubic feet of recoverable helium in proved reserves of helium-bearing natural gas in the US. In 1957, approximately 4 billion cubic feet of helium were available from the natural gas produced and marketed from these proved reserves. Because of the lack of plant capacity, less than 10 percent of this available helium was recovered; the remainder was irretrievably lost. The Department of the Interior is planning an expansion of plant capacity which would permit the conservation of most of the helium now being wasted.

3. Production, Technology, and Cost. 40/

More than 2 billion cubic feet of helium have been produced in the US since large-scale production began in 1921. Before World War II the annual production of helium in the US never exceeded 16 million cubic feet and averaged less than one-half of that amount. In 1944, production reached a peak of 137 million cubic feet as the result of an extensive expansion of plant capacity. In 1953 the wartime peak was surpassed and in the fiscal year 1957, 282 million cubic feet of helium were produced.* The current rate of production of helium is approaching one million cubic feet daily.

The technology for extracting helium from natural gas, which has been developed by the Bureau of Mines, is based on well-known physical laws and involves the use of extremely low temperatures and high pressures. The incoming natural gas is cooled to a temperature below the liquefaction point of its hydrocarbon components (-255° F). At this temperature the mixture of helium and nitrogen is recovered as a vapor and treated to remove hydrogen. This vapor is compressed and further cooled to -320° F, a process which liquefies the nitrogen and yields 98 percent pure helium vapor. This helium then is refined to 99.5 percent purity by cooling in a liquid nitrogen bath at -343° F. A final purity of more than 99.99 percent is achieved by passing the helium through activated charcoal maintained at the temperature of liquid nitrogen. This process is shown graphically in Figure 2.** An aerial view of the largest helium plant in the US is shown in Figure 3.**

The gradual improvement of technology for extracting helium and the increased volume of natural gas processed for this purpose have

* This amount includes about 40 million cubic feet of helium withdrawn from underground storage in the Cliffside Field and reprocessed.
** Following p. 10.

served to reduce the cost of producing helium in the US. The sharp increase in production and decrease in cost are indicated by the following tabulation:

| Year | Production (Thousand Cubic Feet) | Cost (US $ Per Thousand Cubic Feet) |
|---|---|---|
| 1921 | 241 | 525 |
| 1925 | 8,889 | 51 |
| 1930 | 9,801 | 14 |
| 1944 | 137,268 | 5 to 7 |

The foregoing costs represent primarily expenses incurred in operation and maintenance and determined the prices at which helium was sold by the Bureau of Mines to other US Government agencies. Sales of helium to private consumers always included extra charges to cover the estimated costs of depreciation and interest, and since July 1951 these costs also have been included in the prices paid by US Government agencies. The current price of helium is US $15.50 per 1,000 cubic feet.*

4. Uses. 41/

Historically the US Navy has been the principal consumer of helium, having received 54 percent of total production during 1921-55, primarily for lighter than aircraft. Consumption by other components of the Department of Defense, by the Atomic Energy Commission, and by private industry is rapidly increasing, however, as shown by Table 3.** Some of the strategic uses forecast for the fiscal year 1960 are shown in Table 4.*** 42/

In recent years the scarcity of helium has limited commercial sales to essential needs, usually related to national defense. Such uses, predominantly metallurgical, include heli-arc welding and the production and fabrication of magnesium, titanium, and other metals in which a helium atmosphere is essential. Other essential uses are the detection of leaks, medicinal purposes, and experiments in research laboratories.

* A discount is allowed to hospitals and certain other specialized consumers of minor quantities.
** Table 3 follows on p. 11.
*** Table 4 follows on p. 12.

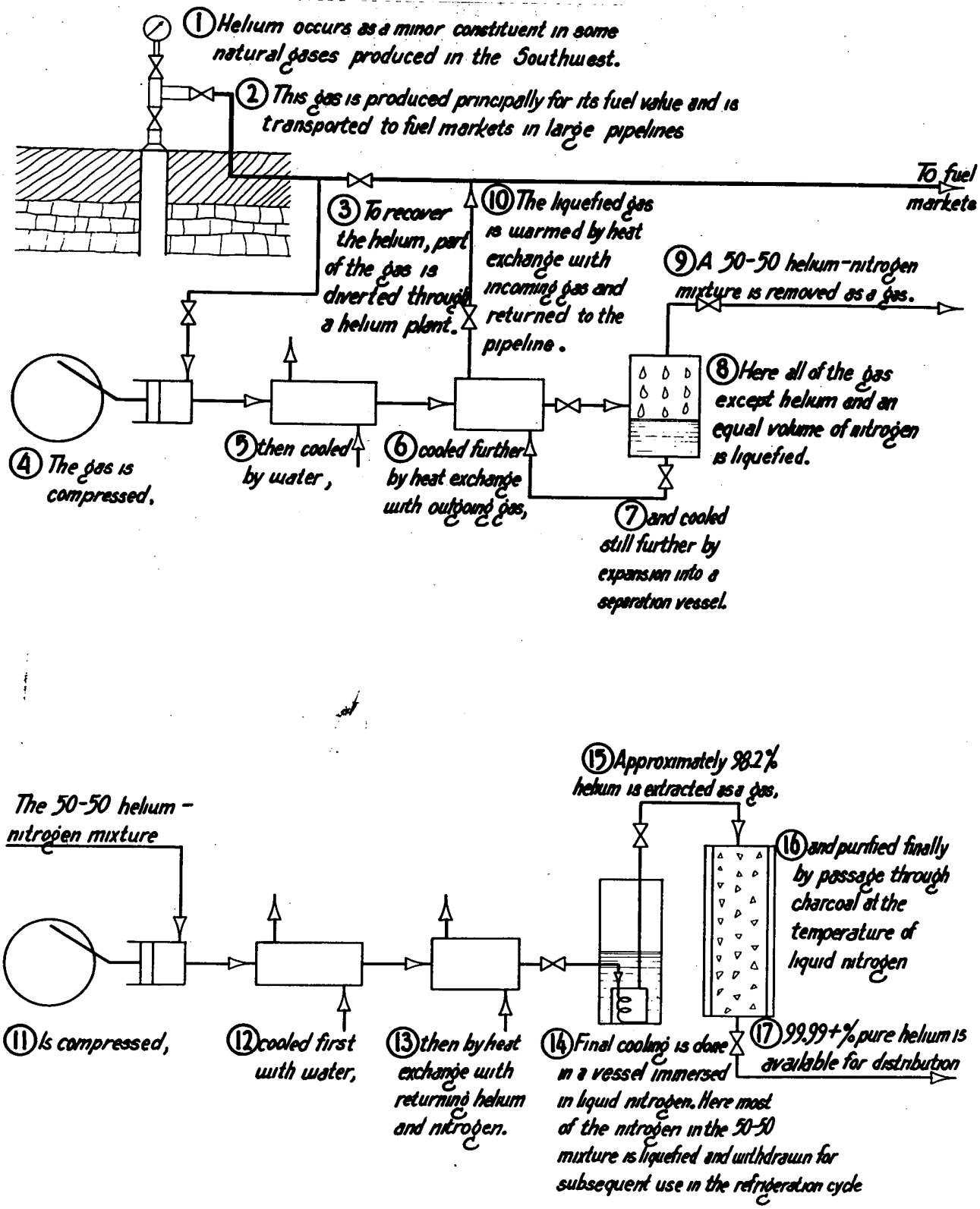



Figure 2. Simplified Flow Diagram of the Helium Production Process

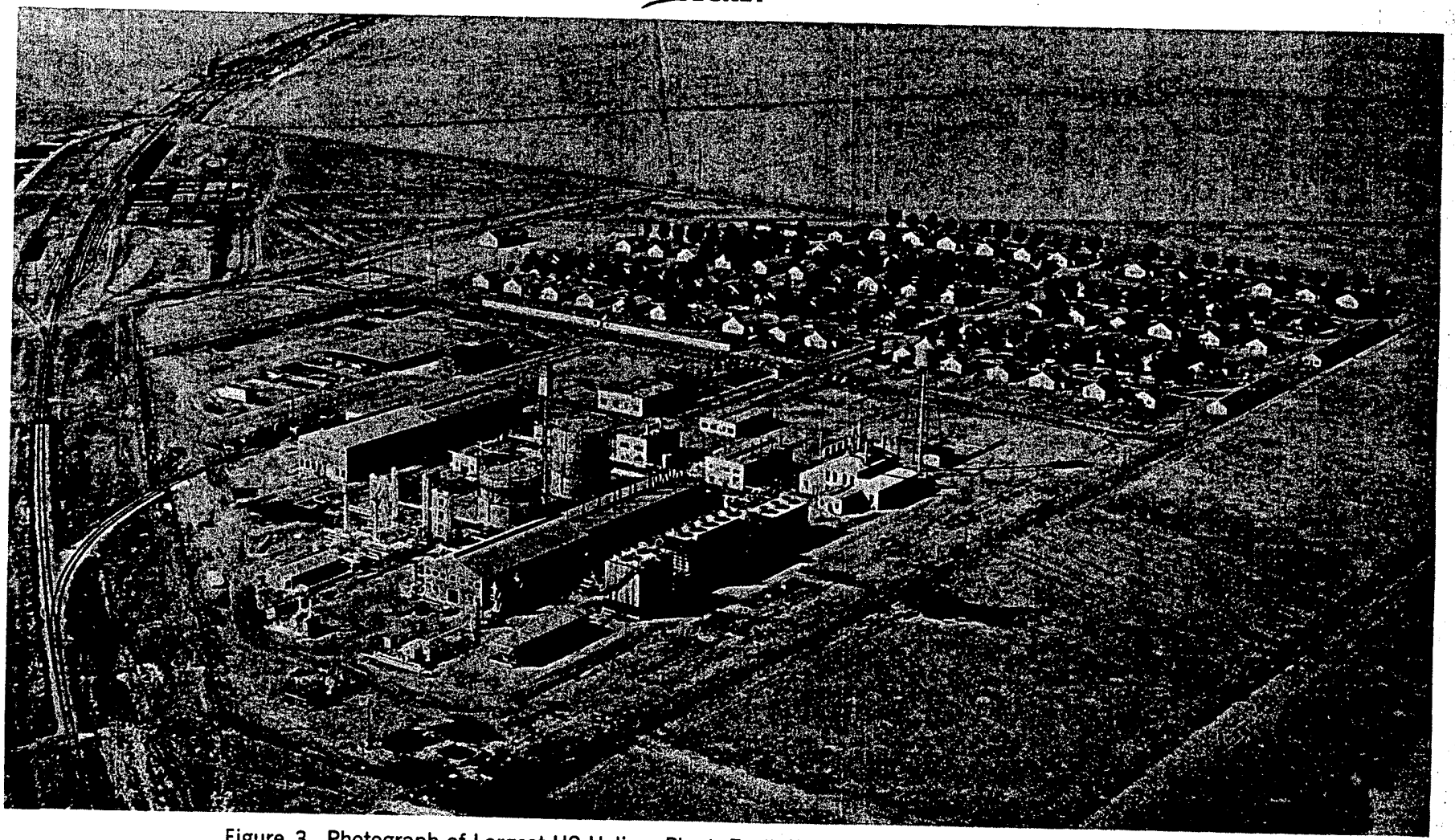


Figure 3. Photograph of Largest US Helium Plant, Exell, Texas, 20 Miles North of Amarillo, Texas

Table 3

Estimated Requirements for Helium in the US, by Consumer a/
Fiscal Years 1958-60

Million Cubic Feet

| Consumer | Fiscal Year 1958 | 1959 | 1960 |
|---|---|---|---|
| Government | | | |
| Department of Defense | 215.2 | 245.9 | 246.4 |
| Atomic Energy Commission | 75.5 | 90.1 | 94.0 |
| Weather Bureau | 11.0 | 12.0 | 13.0 |
| Other | 2.0 | 2.0 | 2.0 |
| Total | 303.7 | 350.0 | 355.4 |
| Private Industry | | | |
| Total | 100.0 | 120.0 | 140.0 |
| Grand total | 403.7 | 470.0 | 495.4 |

a. 43/

Table 4

Estimated Requirements for Helium in the US, by Use a/
Fiscal Year 1960

| Use | Amount (Million Cubic Feet) |
|---|---|
| Department of Defense | |
| Guided missiles | 92.6 |
| Aerology | 54.4 |
| Aeronautical research b/ | 50.2 |
| General stores | 25.6 |
| Airships | 17.0 |
| Welding | 6.0 |
| Breathing atmospheres | 0.5 |
| Nuclear reactors | 0.1 |
| Total | 246.4 |
| Atomic Energy Commission | |
| Production | 62.2 |
| Military applications | 19.8 |
| Development of reactors | 12.0 |
| Total | 94.0 |
| Other | |
| Total | 155.0 |
| Grand total | 495.4 |

a. 44/
b. Including the National Advisory Committee for Aeronautics.

APPENDIX B

## PRODUCTION OF HELIUM IN THE USSR

There is a limited amount of fragmentary data on production of helium in the USSR. Inasmuch as this information is generally qualitative rather than quantitative and frequently of questionable reliability, these data are inadequate for estimating the volume of Soviet production. The information now available may be summarized as follows:

1. As previously indicated, Soviet interest in production of helium dates back at least to 1934.*

2. In 1940 a German engineering journal listed a plant at Dergachevskiy /Rayon/ that extracted helium from natural gas. 45/ The capacity of the plant was given as 13,614 cubic meters (480,765 cubic feet) of natural gas per day, and the helium content of the gas as 0.1 percent. Compared with the gas processed in the US, this helium content is very low. At helium plants in the US the residual natural gas remaining after the helium has been extracted still contains 0.1 to 0.2 percent helium. If it is assumed that one-half of the helium in the natural gas was extracted in the plant in Dergachevskiy and that it operated continuously at the stated capacity, the annual production of helium would have amounted to 87,940 feet. This represents about one-third of the helium produced in the US in 1921.

3. During World War II, four helium plants were observed and described by prisoners of war. 46/ One of these plants -- said to be experimental -- was located at Dergachi, which is in Dergachevskiy Rayon, Khar'kovskaya Oblast, and may be the plant previously identified as being in Dergachevskiy. Another helium plant, reportedly on the island of Zhiloy in Azerbaydzhan ASSR, processed natural gas from local wells from 1943 to 1946, when the gas was depleted. Additional helium plants were reported at Saratov and Stalingrad, but no adequate information was given concerning their size or operations.

4. A prisoner of war employed as a construction helper in Moscow from June 1947 to October 1949 reported he worked on a helium factory. 47/ This factory may have been connected with the plant that received US equipment,* where the liquefaction of natural gas on a large scale was reported to have begun in 1954. 48/ Natural gas

* See 2, a, p. 4, above.

is available to this plant from two sources, the Dashava-Moscow pipeline and the Saratov-Moscow pipeline. The nitrogen content of the gas from Dashava is 0.63 percent, and that of the gas from Saratov is 3 percent. The Saratov-Moscow pipeline is one of the principal outlets for natural gas from the Ural-Volga area, which has been identified as a probable source of helium.* It may be assumed, therefore, that the natural gas from the Saratov-Moscow gas pipeline contains recoverable quantities of helium. On the basis of the data available 49/ the plant at Moscow could produce as much as 10 million cubic feet of helium annually, which amount is equivalent to production in the US in 1930.

5. A bulletin published by the Bureau of Mines in 1952 contained a bibliography covering all technical and scientific articles pertaining to helium that were known to have been published before 1 January 1947. 50/ A total of 2,616 items were cited from 408 journals in the US and abroad. Of this total, 51 items were cited from Soviet journals. Of the 160 items classified under "Production of Helium," the USSR accounted for only 2, which were listed as follows:

| Item Number | Description |
|---|---|
| 466 | Cherepennikov, A.A. (Separating Helium from a Gas Mixture). Russian Patent 25,598, March 31, 1932. |
| 500 | Kvasha, G.I. (The Helium Industry in the United States). Gazovoe Byuro "Soyuzgeolrazvedka," Petrograd. Prirodnuie Gazui, Vol. 2, 1931, pp. 156-168. [sic] |

This bibliography indicates that before 1947 very little information on production of helium was published in the USSR, at least in unclassified publications.

6. An article published in the USSR in January 1957 discussed briefly "the productivity of the presently-operating installations for separating helium" from natural gas, but the article did not reveal the number of plants or quantity of helium being produced, or the amount of the natural gas being processed. 51/ A statement that certain proposed "technological and design changes will permit lowering considerably the cost of commercial helium, which yields a saving up to 12.5 million rubles a year in the operation of one aggregate" might indicate the approximate level of Soviet production of helium through a comparison

* See 1, b, (1), p. 2, above.

of the costs of producing helium in the US and the USSR. The official rate of exchange, 4 rubles to US $1, would indicate a saving of US $3,125,000. A more realistic rate of exchange, 10 to 1, indicates a saving of US $1,250,000. In the fiscal year 1955 the total cost of producing helium in the US was about US $3 million. 52/ These figures do not permit an estimate of production of helium in the USSR, but they suggest an avenue of approach if additional data become available.

7. In July 1957, at the All-Union Conference on Low Temperature Physics in Moscow, Dr. Peter Kapitsa stated that the Institute of Physical Problems was expected to provide large quantities of liquid helium in the very near future. 53/

## APPENDIX C

## METHODOLOGY

The method employed to estimate the availability of helium was that of analogy with conditions in the US. Except for the effect of technology on availability,* the analogous factors are natural rather than artificial and therefore are not subject to differences in the economic capabilities of the two countries. These natural factors are primarily geological and are well established with respect to the occurrence and availability of helium in the US. Data on the geology of the USSR are sufficient to establish the analogous conditions governing the occurrence and availability of helium in that country.

Data on the distribution of helium in natural gas in the US and the geological conditions under which it occurs** were derived from the source cited and were discussed with technologists in the Bureau of Mines, who verified them in principle. These conclusions were verified also by a study of the manuscript of a report prepared by the Bureau of Mines and scheduled for publication. 54/ This report contains analyses of 1,577 samples of natural gas analyzed since 1947.

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* See 2, a, p. 4, above.

** See Table 2, Appendix A, p. 8, above.

## APPENDIX D

## GAPS IN INTELLIGENCE

The primary gap in intelligence on helium in the USSR is information on the number, location, capacity, and production of plants for the extraction of helium. In the absence of such details the ideal basis for estimating the quantity of helium available from a region producing helium-bearing natural gas is by using the data on production of natural gas by the region and the average content of helium of the gas. Such data are not available on regions producing natural gas in the USSR.

Many of the available analyses of natural gas in the USSR refer to individual wells rather than to fields or larger areas. With one exception,* Soviet analyses do not show the helium content of natural gas. Such analyses follow the practice of including helium with the nitrogen, so that helium, if any, must be estimated. Additional analyses of natural gas in the USSR which show helium as a separate component are needed.

* See 1, b, (1), p. 2, above.

APPENDIX E

SOURCE REFERENCES

Evaluations, following the classification entry and designated "Eval.," have the following significance:

| Source of Information | Information |
|---|---|
| Doc. - Documentary | 1 - Confirmed by other sources |
| A - Completely reliable | 2 - Probably true |
| B - Usually reliable | 3 - Possibly true |
| C - Fairly reliable | 4 - Doubtful |
| D - Not usually reliable | 5 - Probably false |
| E - Not reliable | 6 - Cannot be judged |
| F - Cannot be judged | |

"Documentary" refers to original documents of foreign governments and organizations; copies or translations of such documents by a staff officer; or information extracted from such documents by a staff officer, all of which may carry the field evaluation "Documentary."

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